Health Consultation

Arizona Windsong Water Company

SANDERS, APACHE COUNTY, ARIZONA

Prepared by the

Arizona Department of Health Services
Office of Environmental Health
Environmental Health Consultation Services

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Summary

INTRODUCTION

In the *Arizona Windsong Water Co. Health Consultation:* the Arizona Department of Health Services' (ADHS') top priority is to ensure that the community and residents have the best information possible to safeguard their health.

This report was written in response to a request from the Arizona Department of Environmental Quality (ADEQ) regarding the uranium detected in the private Arizona Windsong Water Co. (AWWC) in Sanders, AZ. Uranium was found to exceed the Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) in water samples. The community members have expressed their concerns about the water quality. ADHS conducted an evaluation to determine if the uranium is at or above levels of public health concern.

CONCLUSIONS AND BASIS FOR DECISION

Based on the available information, ADHS reached the following conclusions:

- The uranium found in the water samples is not expected to harm the health of adults and children > 1 year old, because the estimated daily exposure doses were below EPA's reference dose or the lowest-observed-adverse-effect-levels (LOAELs).
- Children < 1 year old may have a slightly increased risk of adverse health outcomes based on the evaluation of estimated daily exposure doses from past, current, and potential future exposures. Therefore, children 0 to 12 months of age should not consume (drink directly, drink formula prepared with, or eat foods prepared with) the water, based on the evaluation results from past and current exposures. ADHS recommends the use of an alternative source of water, such as bottled water for children 0 to 12 months of age.

NEXT STEPS

- ADHS will attend public meetings to discuss the process of preparing health consultations and community concerns upon the community's request. ADHS will make presentations, develop handouts, and provide additional assistance as necessary to notify the property owners and residents regarding the findings of this health consultation.
- ADHS will notify ADEQ regarding the findings of this report and work with ADEQ to evaluate the protectiveness of mitigation action plans.

	• At the request of ADEQ or the community, ADHS will continue to review and evaluate data provided for this site.
FOR MORE INFORMATION	If you have concerns about your health, you should contact your health care provider. Please call ADHS at 602-364-3118 if you have questions about this report.

Purpose

The Arizona Department of Health Services (ADHS) received a request from the Arizona Department of Environmental Quality (ADEQ) to address concerns regarding uranium detected in the privately-owned Arizona Windsong Water Co. (AWWC) in Sanders, AZ. The purpose of the request was to evaluate the potential health risks associated with exposure to uranium detected in the water distributed by the AWWC.

Background and Statement of Issue

The AWWC provides water to the Park Estates Subdivision (a mobile home community). Uranium was found to exceed the Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) in water samples since 2009, based on the ADEQ's online record. The MCL is the highest level of a chemical that is allowed in public drinking water systems. MCLs are determined by the EPA and set as close to Maximum Contaminant Levels Goals (MCLGs) as possible using the best available treatment technology and taking cost into consideration. MCLGs are the levels of each chemical in drinking water; a chemical found below its specific MCLG is not expected to pose a risk to human health. MCLGs are non-enforceable public health goals, while MCLs are enforceable standards. The MCLG for uranium in drinking water is 0 parts per billion (ppb), and the MCL for uranium is set at 30 ppb, which is considered to be protective of health for both children and adults for a life time of exposure (70 years).

ADEQ released a public notice to inform the community about the violation. The community members and an Environmental Justice Group, Tolani Lake Enterprises (TLE), have expressed their concerns about the water quality. ADHS conducted an evaluation to determine whether the uranium is at or above levels of public health concern.

Discussion

General Assessment Methodology

ADHS generally follows a three-step methodology to assess public health issues related to environmental exposures. First, ADHS obtains representative environmental data for the site of concern and compiles a comprehensive list of site-related contaminants. Second, ADHS identifies exposure pathways, and then uses health-based comparison values to find those contaminants that do not have a realistic possibility of causing adverse health effects. Finally, for the remaining contaminants, ADHS reviews recent scientific studies to determine if exposures are sufficient to impact public health.

Available Environmental Data

ADHS used the water sampling data collected from 2003 to present to evaluate potential human exposure. No water sampling results were available from 2004 to 2008, 2010, and 2012 (Table 1.) The sampling data were provided by ADEQ, and analyzed by the Radiation Safety

Engineering, Inc. and Mohave Environmental Laboratory. The water samples were collected prior to the entry point to the distribution system (EPDS), which occurs after processing and storage in the water treatment plant, but prior to reaching the first customer.

Table 1. Water sampling results in parts per billion (ppb).

Sampling Date	Uranium (ppb)
03/06/2003	49.4
11/20/2003	69.3
08/20/2009	43.1
09/12/2011	60.6
12/11/2013	65.8
07/08/2014	52.7
10/21/2014	42.4
02/19/2015	38.9
06/16/2015	39.6
*95% UCL**	*58.5*
Most recent	*39.6*

*95% UCL: 95% Upper Confidence Level of the arithmetic mean

Exposure Pathway Analysis

Identifying exposure pathways is important in a health consultation because adverse health impacts from contaminants can only happen if people are exposed to them. The presence of a contaminant in the environment does not necessarily mean that people are actually coming into contact with it. Exposure pathways have been divided into three categories: completed, potential, and eliminated.

There are five elements considered in the evaluation of exposure pathways:

1) a source of contamination
2) a medium such as soil or ground water through which the contaminant is transported
3) a point of exposure where people come into contact with the contaminant
4) a route of exposure by which the contaminant enters or comes into contact with the body
5) a receptor population (i.e. exposed population)

Completed pathways exist when all five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring presently. In a potential exposure pathway, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. In eliminated pathways, at least one of the five elements is or was missing, and is not expected to be present in the future. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

Exposure to Public Drinking Water: Residents can be exposed to chemicals from using the water for domestic purposes. Typical exposures to contaminants through potable water include dermal exposure (from bathing and showering) and ingestion exposure (from drinking and using water for cooking). Metals (e.g. uranium) tend not to be absorbed through the skin, and are not likely to be inhaled by people as aerosols while showering because they are not volatile (i.e. do not evaporate); therefore, bathing and showering are not routes of exposure.

ADHS further evaluated the completed and potential exposure pathways to determine whether realistic exposures are sufficient in magnitude, duration or frequency to result in adverse health effects (Table 2.)

Table 2. Exposure Pathways Analysis

Exposure Pathway Elements					Time frame	Type of Exposure Pathway
Source	Medium	Point of exposure	Route of exposure	Potentially exposed population		
Public water supply	Water	Residences, tap	Ingestion	Residents	Past	Completed
					Current	Completed
					Future	Potential

Comparison to Health-based Comparison Values for Groundwater Well Samples

Health-based comparison values (CVs) are screening tools used to evaluate environmental data relevant to exposure pathways. These comparison values are quite conservative, and usually include uncertainty factors that account for the most sensitive populations. Adverse health effects are not expected to occur if an exposure concentration/dose is below a CV. However, an exposure concentration/dose at or above the CV doesn't automatically mean adverse effects will occur. Rather, it means that there is a need to conduct a site-specific exposure scenario evaluation. The health risk for an individual depends on individual human factors (e.g. personal habits, occupation, and/or overall health), and site-specific environmental exposure factors (e.g. duration and amount of exposure). Therefore, the comparison values should not be used to predict the occurrence of adverse health effects without looking at site-specific conditions.

In this health consultation, ADHS evaluated exposures to past and current levels of uranium (Table 3). The residents' exposure to uranium is considered a long-term chronic exposure because the residents have been exposed longer than 1 year (from 2003 to 2015). The exposure levels were determined based on the 95% UCL of all data points (58.5 ppb, representing past, chronic exposure), and the most current data point (39.6 ppb, representing current/future potential exposure), respectively. ADHS also considered the intermediate exposure (more than 14 days but less than 1 year) scenario. The exposure concentration was determined based on the 95% UCL of water sampling results from July 2014 to June 2015. All of the exposure levels exceeded EPA's MCL of 30 ppb. MCLs are legally enforceable levels that are determined based

on the best available technology and cost of treatment. They are meant to be protective for children and adults for a lifetime exposure. When a chemical concentration is above its MCL, it does not necessarily pose an immediate public health threat: rather, there is a need for further testing or treating until the concentration falls below the MCL.

During the initial screening process, ADHS compared the exposure levels to the intermediate (Environmental Media Evaluation Guide (EMEG)) and chronic (Reference Dose Media Evaluation Guide (RMEG)) comparison values developed by the Agency for Toxic Substances and Disease Registry (ATSDR). Both EMEGs and RMEGs are health-based guidelines that have built-in uncertainty or safety factors, making them considerably lower than the levels at which health effects have been observed. If a substance is found at concentrations below the EMEG or RMEG, the contaminant is not expected to pose a public health concern, and no further evaluation is required. However, these values serve only as screening values, and are not indicators of public health hazard. When a substance is found at a concentration above the EMEG or RMEG, it is an indication that ADHS should further examine the potential harmful effect levels reported in the scientific literature and more fully review the potential for negative health outcomes.

ATSDR develops EMEGs using ATDSR's Minimum Risk Level (MRL) and default assumptions, which account for variation in intake rates between adults and children. MRLs are ATSDR estimates of the daily human exposure to hazardous substance that is likely to be without appreciable risk of adverse non-cancerous health effects over a specified duration of exposure. The uranium EMEGs are 7 ppb for adults, and 2 ppb for children[1].

ATSDR develops RMEGs using EPA's Reference Dose (RfD) and default assumptions, which account for variation in intake rates between adults and children. RfDs are EPA estimates that have uncertainty factors built in and are the daily lifetime dose of a substance that is unlikely to cause harm in humans. The uranium RMEGs are 110 ppb for adults and 30 ppb for children.[2]

As shown in Table 3, the 95% UCL of measurements from July 2014 to June 2015 exceeded the adult and the child EMEG. Both the 95% UCL and the most current measurement exceeded the child RMEG but not the adult RMEG. Therefore, ADHS conducted further evaluation.

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[1] $EMEG = \frac{MRL \times Body\ Weight}{Ingestion\ Rate}$. Therefore, EMEG for adult = $\frac{0.0002\ \frac{mg}{kg.day} \times 70\ kg}{2\ \frac{L}{day}} = 0.007\ \frac{mg}{L} = 7\ ppb$, and EMEG for children = $\frac{0.0002\ \frac{mg}{kg.day} \times 10\ kg}{1\ \frac{L}{day}} = 0.002\ \frac{mg}{L} = 2\ ppb$.

[2] $RMEG = \frac{RfD \times Body\ Weight}{Ingestion\ Rate}$. Therefore, RMEG for adult = $\frac{0.003\ \frac{mg}{kg.day} \times 70\ kg}{2\ \frac{L}{day}} = 0.11\ \frac{mg}{L} = 110\ ppb$, and RMEG for children = $\frac{0.003\ \frac{mg}{kg.day} \times 10\ kg}{1\ \frac{L}{day}} = 0.03\ \frac{mg}{L} = 30\ ppb$.

Table 3. Comparison to Initial Screening Values for Intermediate (More than 14 days but Less than 1 year) and Long Term Exposure (More than 1 Year)

	Uranium concentration (ppb)	Comparison Values (ppb)
95% Upper Confidence Level of All Measurements (past exposure)	58.5	EPA MCL[1] = 30 ppb ATSDR EMEG[2]: Children = 2 ppb; Adults = 7 ppb ATSDR RMEG[3]: Children = 30 ppb; Adults = 110 ppb
95% Upper Confidence Level of Measurements from July 2014 to June 2015 (intermediate exposure)	50.9	
Most Current Measurement (current/potential future exposure)	39.6	

1. EPA MCL (maximum contaminant level): is an enforceable standards set by EPA for the highest level of a contaminant allowed in drinking water. MCLs are set as close to MCL goals as possible using the best available treatment technology and taking cost into consideration.
2. ATSDR EMEG (environmental media evaluation guide): EMEGs represent concentrations of substances in water, soil, and air to which humans may be exposed during a specified period of time (acute, intermediate or chronic) without experiencing adverse health effects.
3. ATDSR RMEG (reference dose media evaluation guide): substances found at concentrations below RMEG are not expected to pose public health hazards. It serves only as a screening value, and is not an indicator of public health hazard.
4. RMEG and EMEG are developed from RfD and MRL, respectively, which were derived based on oral exposure to soluble uranium compounds. Soluble uranium compounds are more toxic than insoluble uranium compounds.

Public Health Implications*: This section will provide general toxicological information and site-specific exposure evaluation for each contaminant of interest.*

Uranium:

Uranium (U) is a natural and commonly occurring radioactive, heavy metal. The most common natural uranium is a mixture of three types of uranium: U-234, U-235, and U-238. Uranium atoms are unstable; therefore, they decay into other atoms in order to reach a more stable condition. During this process, they emit radioactive alpha-particles (or energy).

Uranium has a very low level of radioactivity because of its extremely long half-life (4.5 billion years). Its radioactivity is several million times less radioactive than radon; thus, the major health concern resulting from exposure to uranium is due to its chemical toxicity. Animal studies have shown that water-soluble forms of uranium can cause kidney problems. Kidney effects have been seen in humans that have experienced acute poisoning incidents (ATSDR 2013).

Although radiation has been shown to cause cancer, no evidence has been found linking the ingestion of uranium to human cancer. Limited data on animal studies have not reported tumor growth after feeding uranium compounds to rats or dogs. The US EPA has not identified uranium as carcinogenic (ATSDR 2013).

Site-specific Evaluation

ADHS further calculated the site-specific chronic daily exposure doses for both past and current/future exposure. Listed below are the exposure assumptions and estimated daily exposure doses for different age groups.

(1) Exposure assumptions: no site-specific water intake rates are available. ADHS used the recommendations provided by ATSDR. These values are based on the EPA 2011 Exposure Factors Handbook, which includes two exposure scenarios:

- Reasonable Maximum Exposure (RME): referring to persons who are at the upper end of the exposure distribution (about the 95%). The RME assesses exposures that are higher than average but still within a realistic exposure range. In this case, this would refer to individuals who have a very high water intake rate.
- Central Tendency Exposure (CTE): referring to individuals who have an average or typical water intake rate.

Age Groups	Drinking Water Intake			Exposure Frequency	Body Weight (Kg)
	RME (L/day)		CTE (L/day)		
Child Birth to < 1 yr	1.113		0.504	1	7.8
Child 1 to < 2 yr	0.893		0.308	1	11.4
Child 2 to < 6 yr	0.977		0.376	1	17.4
Child 6 to < 11 yr	1.404		0.511	1	31.8
Child 11 to <16 yr	1.976		0.637	1	56.8
Child 16 to <21 yr	2.444		0.77	1	71.6
Adults	3.092		1.227	1	80

(2) Estimated daily exposure doses for past, chronic exposure scenario for age-specific groups

Age Groups	Estimated Daily and Annual Dose		
	RME		CTE
	mg/kg/day		mg/kg/day
Child Birth to < 1 yr	0.0083		0.0038
Child 1 to < 2 yr	0.0046		0.0016
Child 2 to < 6 yr	0.0033		0.0013
Child 6 to < 11 yr	0.0026		0.0009
Child 11 to <16 yr	0.0020		0.0007
Child 16 to <21 yr	0.0020		0.0006
Adults	0.0023		0.0009

(3) Estimated daily exposure doses for past, intermediate exposure scenario for age-specific groups

Age Groups	Estimated Daily and Annual Dose		
	RME		CTE
	mg/kg/day		mg/kg/day
Child Birth to < 1 yr	0.0073		0.0033
Child 1 to < 2 yr	0.0040		0.0014
Child 2 to < 6 yr	0.0029		0.0011
Child 6 to < 11 yr	0.0022		0.0008
Child 11 to <16 yr	0.0018		0.0006
Child 16 to <21 yr	0.0017		0.0005
Adults	0.0020		0.0008

(4) Estimated daily exposure doses for current/potential future exposures scenario for age-specific groups

Age Groups	Estimated Daily and Annual Dose		
	RME		CTE
	mg/kg/day		mg/kg/day
Child Birth to < 1 yr	0.0057		0.0026
Child 1 to < 2 yr	0.0031		0.0011
Child 2 to < 6 yr	0.0022		0.0009
Child 6 to < 11 yr	0.0017		0.0006
Child 11 to <16 yr	0.0014		0.0004
Child 16 to <21 yr	0.0014		0.0004
Adults	0.0015		0.0006

A Minimal Risk Level (MRL) is an estimate of the daily human exposure to a hazardous substance that is not likely to be result in a noticeable risk of adverse non-cancerous health effects over a specified duration of exposure. ATSDR develops three types of MRLs based on the exposure duration: acute MRLs are for evaluation of 1-14 days of exposure, intermediate MRLs for evaluation of 15 to < 365 days of exposure, and chronic MRLs for evaluation of ≥ 365 days of exposure. ATSDR has developed an oral exposure MRL for intermediate exposure duration, but not for chronic exposure duration. However, according to ATSDR, the intermediate MRL should also be protective for chronic exposure. The intermediate MRL is 0.0002 mg/kg/day; this value is an order of magnitude lower than the EPA chronic Reference Dose (RfD) of 0.003 mg/kg/day.

EPA developed a chronic reference dose for uranium (0.003 mg/kg/day) based on an animal study (Maynard and Hodge 1949). Rabbits, rats and dogs were fed a diet containing soluble uranium compounds (uranium nitrate hexahydrate) for 30 days. Rat and dog studies were continued for up to 1 year. Rabbits showed greater sensitivity to the uranium toxicity. After 30 days of exposure, moderate to moderately severe kidney damage was observed in the exposed rabbit groups. Initial weight loss was also observed. The lowest dose tested in rabbits (2.8 mg/kg/day) was determined to be the LOAEL. An uncertainty factor of 1,000 was used to account for the inter- and intra-species variability, and to account for the use of the LOAEL instead of a NOAEL (No Observed Adverse Effect Level).

ATSDR developed the intermediate MRL based on a sub-chronic animal study (Gilman et al 1998). Rats and rabbits were exposed to soluble uranium (as uranyl nitrate) containing water for 91 days. The LOAEL identified in the study was 0.06 mg/kg/day for kidney effects in rats. The effects (such as tissue changes at the kidney tubules and glomerulus) are considered to be adverse, but not severe. An uncertainty factor of 300 was used to account for the inter- and intra-species variability (differences among members of the same species and differences between different species, respectively) and for the use of LOAEL instead of a NOAEL. Therefore, the Intermediate MRL calculated = LOAEL/Uncertainty Factors.

Key findings in a series of other long-term studies (Maynard and Hodge 1949 and Maynard et al. 1953) found that kidneys have the ability to repair damage at low doses. At low level exposures (170 mg uranium/kg/day as uranyl nitrate) the kidney tubular epithelium is repaired and on-going exposure does not result in more severe effects. At higher levels of exposure (660 mg uranium/kg/day), tissue repair was observed in the first month. However, with on-going exposure, tubular damage was observed after 6-8 weeks of on-going exposure.

All of the estimated daily exposure doses for the exposed residents in Sanders are above ATSDR's intermediate MRL of 0.0002 mg/kg/day, but all of them were below the LOAEL that was used to develop the intermediate MRL. For the RME groups, the estimated daily exposure doses were about 8 to 40 times lower than the LOAEL. For the CTE groups, the estimated daily exposure doses were about 15 to 150 times lower than the LOAEL. Most of the estimated daily exposure doses were below the EPA's RfD (except: 0-1 year, 1-2 year, 2-6 year in the RME

groups and 0-1 year in the CTE groups under the past chronic and intermediate exposure scenarios; and 0-1 in the RME group under the current/potential future exposure scenario). However, all of the estimated daily exposure doses were well below the LOAEL (2.8 mg/kg/day) that was used to derive the EPA's RfD.

Based on the available information and scientific studies, ADHS determined that the chance of developing adverse health outcomes is low. However, based on the evaluation results of estimated doses from past and current exposures, ADHS recommends that children 0 to < 1 years of age should not consume the water because their kidneys are still developing and could be potentially more susceptible to uranium toxicity than adults.

ADHS Child Health Concern

ADHS recognizes that the unique vulnerabilities of infants and children demand special consideration in communities dealing with contaminants in environmental media. A child's developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Children ingest a larger amount of water relative to body weight than adults, resulting in a higher burden of pollutants in proportion to body size. Furthermore, children often engage in vigorous activities, making them more sensitive to pollution than healthy adults. We do not know whether children are more susceptible than adults to uranium effects. All health analyses in this report take into consideration the unique vulnerability of children.

We do not know whether uranium can harm an unborn child. No scientific human study that has shown birth defects due to uranium exposure has been identified. Some studies showed that when animals were exposed to high levels of uranium during pregnancy, which caused adverse effects in the mothers, have resulted in early death and birth defects in the offspring. However, it is not clear if this can happen in the absence of effects to the mother. Other studies have not found birth effects.

Conclusions

This health consultation evaluated the potential health risks associated with exposure to uranium in public drinking water. The water sampling results were provided by ADEQ. The water samples were collected prior to the entry point to the distribution system (EPDS) which is after processing and storage in the water treatment plant, but prior to reaching the first customer. Based on the available information, ADHS reached the following conclusions:

- The uranium found in the water samples are not expected to harm the health of adults and children > 1 year old, because the estimated daily exposure doses were below EPA's reference dose or the lowest-observed-adverse-effect-levels (LOAELs).
- Children < 1 year old may have a slightly increased risk of developing adverse kidney effects based on the evaluation of estimated daily exposure doses from past, current, and potential future exposure.

Recommendations

ADHS recommends that children 0 to 12 months of age should not consume (drink directly, drink formula prepared with, or eat foods prepared with) the water, based on the evaluation results from past and current exposures. ADHS recommends the use of an alternate source of water, such as bottled water.

Public Health Action Plan

- ADHS will attend public meetings to discuss the process of preparing health consultations and community concerns upon the community's request. ADHS will make presentations, develop handouts, and provide additional assistance as necessary to notify the property owners and residents in the area of the findings of this health consultation.
- ADHS will notify ADEQ regarding the findings of this report and work with ADEQ to evaluate the protectiveness of mitigation action plans.
- ADHS will continue to review and evaluate data provided for this site.

References/Information Sources

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REPORT PREPARATION

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Appendix A

Chronic Daily Intake from Water

$$ED_{water} = \frac{Conc. \times IR \times EF}{BW}$$

ED_{water}: chronic daily exposure via water ingestion (mg/kg/day)
Conc.: chemical concentration in water (mg/L)
IR: water ingestion rate (L/day)
EF: exposure factor (unitless)
BW: body weight (kg)